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Demand Shocks and Economic Fluctuations

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Abstract

This paper studies conditions under which demand-side shocks can generate realistic business cycles in RBC models. Although highly persistent demand shocks are necessary for generating procyclical investment, variable capacity utilization and habit formation can reduce the required degree of persistence.

Keywords: Demand Shocks; Hall's Residual; Real Business Cycles; Crowding Out; Investment Dynamics.

JEL Classification: E12, E13, E21, E22, E32.

*This paper draws heavily from the first part of an earlier working paper, "Fickle Consumers Versus Random Technology: Explaining Domestic and International Comovements" (Yi Wen, Cornell University, 2002). The views expressed are those of the author and do not reflect official positions of the Federal Reserve System. Correspondence: Yi Wen, Research Department, Federal Reserve Bank of St. Louis, P.O. Box 442, St. Louis, MO 63166.

1 Introduction

There has been a growing literature focusing on the business cycle effects of demand side shocks in DSGE models, following the pioneering work of Baxter and King (1991) and Hall (1997).[1] In general equilibrium models, demand side shocks (such as preference shocks to consumption demand or shocks to government spending) have a strong tendency to crowd out investment. This crowding-out effect often leads to counterfactural predictions of investment behavior unless there exist strong enough increasing returns in the production technology (see, e.g., Baxter and King 1991, Benhabib and Wen 2004). However, if the demand shocks are sufficiently persistent, then even in the absence of increasing returns to scale investment can be procyclical and highly volatile. The intuition is that the anticipated higher future demand after a shock can only be met by higher savings. Hence, when the demand shocks (such as urges to consume) are highly persistent, investment increases rather than decreases. Thus standard RBC models have the potential to explain the business cycle by relying on demand-side shocks alone without resorting to technology shocks. This gives RBC models an additional dimension to explain the business cycle, since many episodes of the business cycle in the history were clearly demand drive, such as the Great Depression and the World-War II. Therefore, the RBC theory and the traditional Keynesian view of the business cycle are not necessarily inconsistent with each other as far as the importance of aggregate demand is concerned.

This paper studies the conditions under which demand-side shocks can generate procyclical investment movement. It is shown that for a standard RBC model to generate procyclical and volatile investment, the degree of persistence in demand shocks (measured as the AR(1) coefficient in the shock processes) needs to be close to a random walk. However, factors such as high elasticity of labor supply, variable capacity utilization, high rate of capital depreciation, as well as strong habit formation can all reduce the required degree of persistence in demand shocks in order to generate procyclical investment.[2]

2 The Model

This is a version of the model studied by Baxter and King (1991) without externalities (see Nakajima, 2001, for a more sophisticated model). The representative consumer in the model maximizes the expected utility function

$$E_0 \sum_{t=0}^{\infty} \beta^t \left\{ \ln (c_t - \Delta_t) - a \frac{n_t^{1+\gamma}}{1+\gamma} \right\}$$

[1] For the effects of government spending shocks, see Burnside, Eichenbaum and Fisher (2003) and Benhabib and Wen (2004), among others. For the effects of preference shocks, see Benhabib and Wen (2004), Nakajima (2004), Weder (2001) and Wen (2001, 2002, 2004), among others.

[2] Since government spending shocks generate almost identical impulse responses to those under preference shocks with respect to investment, output, and employment, only preference shocks are considered in this paper.

subject to

$$c_t + k_{t+1} - (1-\delta)k_t = k_t^{\alpha} n_t^{1-\alpha},$$

where Δ represents random shocks to the marginal utility of consumption, which generates the urge to consume. I assume that Δ follows a stationary $AR(1)$ process in log:

$$\log \Delta_t = (1-\rho)\log \Delta + \rho \log \Delta_{t-1} + \varepsilon_t,$$

where $0 \leq \rho < 1$ measures the persistence of the shocks.

Proposition 1. Output, consumption, and hours always respond positively to the consumption shock Δ. However, Investment responds positively to the consumption shock Δ if and only if the shock is persistent enough. When $\gamma = 0$, positive responses for investment are possible if and only if

$$\rho > \frac{\alpha}{\alpha + (1-\alpha)(1-\beta(1-\delta))}.$$

Proof (See Wen, 2002, http://www.arts.cornell.edu/econ/cae/rbc4.pdf).

The first part of proposition 1 is well known (e.g., see Baxter and King, 1991). The second part of proposition 1 regarding investment behavior, however, has gone unnoticed in the literature. The intuition for proposition 1 is as follows. An increase in Δ creates an urge to consume by increasing the marginal utility of consumption. However, the resulting increase in consumption is smaller than the increase in Δ, otherwise the original consumption allocation would not have been optimal. Consequently, the price of leisure (or the utility value of real wage) goes up, rendering it optimal to increase labor supply. Hence in equilibrium, employment and output also increase in response to Δ. However, if the shock is transitory, the marginal utility of current consumption exceeds the marginal utilities of future consumption, hence savings (investment) are crowded out. When the shock is highly persistent, on the other hand, the marginal utilities of future consumption increase, rendering it optimal to increase current savings (investment). This gives rise to still higher employment, generating persistent and strong comovements in output, consumption, employment and investment.

Note that the required degree of persistence for consumption shocks depends on other parameters in the model as well. For example, when $\delta = 1$, a positive change for investment is optimal even when the shock is short lived (i.e., it requires only $\rho > \alpha$). Given that α is between 0.3 to 0.4 in the data, very mild persistence of consumption shocks is able to induce positive responses from investment. The intuition is that a higher value of δ increases the marginal impact of investment on the capital stock, hence the marginal rate of return to investment increases despite the fact that the average rate of return to investment decreases as δ gets larger. Hence, less persistent shocks are required to induce positive investment. On the other hand, when δ is very small (say 0.025), then $\rho > 0.925$ is required to induce positive investment in the model when $\alpha = 0.3, \beta = 0.99, \gamma = 0$. The parameter ρ not only determines the sign of investment but also its volatility. A larger value of ρ reduces the volatility of consumption and increases the volatility of investment in response to consumption shocks. The required persistence for generating investment volatility consistent with the U.S. data is much higher than that for generating positive investment. For example, to generate investment responses that are more volatile than consumption requires $\rho > 0.999$ when $\alpha = 0.42$ and $\gamma = 0.25$.

Figure 1 presents the impulse responses of output, consumption, investment and hours to one standard deviation consumption shock when the parameters are calibrated at $\alpha = 0.3, \beta = 0.99, \gamma = 0, \delta = 0.025$, $\frac{\Delta}{c} = 0.1$, and when the persistence parameter takes two possible values: $\rho = 0.90$ and $\rho = 0.98$. The left window of figure 1 presents the case for $\rho = 0.90$. It shows that both employment and output respond positively to the consumption shock. Investment, however, responds negatively to the consumption shock due to crowding out. The right window of figure 1, in contrast, shows that the responses of investment become strongly positive when the shock is more persistent (close to random walk). This is so because the only way to sustain such highly persistent increases in consumption demand is to build up larger production capacity by investing more.[3] There are many ways to reduce the required persistence of preference shocks in order to generate volatile and procyclical investment. Several examples are provided below.

2.1 Variable Capacity Utilization

Variable capital utilization can reduce the required degree of persistence in preference shocks for generating procyclical investment because variable capacity utilization reduces the crowding-out pressure on investment by enhancing the flexibility (elasticity) of aggregate supply. For example, let the production technology be redefined as $y = (ek)^{\alpha} n^{1-\alpha}$, where e denotes the rate of capital utilization. Let e be related to the rate of depreciation according to $\delta_t = \frac{1}{\theta} e_t^{\theta}$ ($\theta > 1$, see Greenwood et al., 1988). Then under the same parameter calibrations as above, the required value of ρ for inducing positive investment is reduced to 0.88.

[3] The phenomenon that the predicted volatility of consumption relative to output decreases as preference shocks become more persistent is interesting. Intertemporal risk diversification suggests that consumption volatility relative to income increases as income shocks become more persistent. For example, in the current model consumption volatility is only about 10% of output volatility when technology shocks are *i.i.d.*, and consumption becomes as volatile as output when technology shocks are permanent. In contrast, consumption is about 10 times more volatile than output when preference shocks are *i.i.d.* and its volatility is only about 40% of output volatility when preference shocks are permanent. This is so because the principle of risk diversification works differently under preference shocks than under technology shocks. When the urgency to consume is transitory, agents opt to use up savings to satisfy current needs, leaving production level roughly constant. When the urgency to consume is permanent, however, individuals opt to produce more than currently needed so as to increase savings to satisfy future needs. This means that in an endowment economy where the income level is constant, current savings decrease less when the urgency to consume is more persistent. In other words, consumers are willing to pay a risk premium to avoid a less severe but more persistent urge to consume.

2.2 Non-Separable Preferences

Non-separable preferences are common in the open-macro business cycle literature. If consumption and leisure are better substitutes, for example, then the required persistence of consumption shocks for generating procyclical investment can also be reduced. For example, let the utility function be defined as $u(c,n) = \left\{[c-\Delta]^{\mu}[1-n]^{1-\mu}\right\}^{\gamma}\frac{1}{\gamma}$. It can be shown that the larger the value of γ, the lower is the required value of ρ to generate procyclical investment. When $\gamma = 1$, the required value of ρ is below 0.9 without variable capacity utilization. With capacity utilization, the required value of ρ can be further reduced down to 0.85. The intuition is that when consumption and leisure are substitutes, higher consumption can be associated with lower leisure, implying that increasing labor supply is less costly. This enhances the elasticity of output supply and reduces the crowding-out effect of consumption on investment.

2.3 Endogenous Persistence

Habit formation has the effect of rendering transitory preference shocks endogenously persistent. Consequently, in order to generate positive and persistent comovements between investment and output, consumption shocks do not need to be persistent if consumption is habit forming. To study the effect of habit formation, define the utility function of consumption as $u(c) = \log(c_t - bc_{t-1} - \Delta_t)$, where the parameter $b \in (0,1)$ measures the degree of habit formation. The parameter b has been estimated by many people in the empirical literature and the results change substantially depending on the instrument variables used and whether monthly or quarterly data are used. According to Ferson and Constantinides (1991), best point estimates of b for U.S. quarterly data lie between 0.95 and 0.97 with standard errors of 0.05 and 0.01 respectively, depending on the number of lags chosen for the financial instrument variables. I choose $b = 0.95$ as my benchmark value for habit persistence.[4]

The dynamic effects of habit formation are shown in figure 2.[5] The left window presents the responses of output, consumption, hours and investment to an *i.i.d.* consumption shock (i.e, $\rho = 0$). It shows that investment responds positively to the shock despite the fact that the shock is transitory. This is so because the representative agent anticipates the impact of the shock on consumption to persist due to rational habit formation, rendering it optimal to increase investment so as to meet the anticipated increases in future consumption demand. Thus, habit formation effectively renders the impact of transitory consumption shocks *endogenously* persistent. The right window presents impulse responses of the variables to a persistent consumption shock ($\rho = 0.9$). It

[4] The results are similar if $b = 0.9$.

[5] The other parameter values are kept the same except that $\frac{\Delta}{c}$ is decreased from 0.1 to 0.045 in order to satisfy the condition: $1 - b - \frac{\Delta}{c} > 0$. The value of $\frac{\Delta}{c}$ affects the volatilities of consumption and other variables, but the relative second moments of the model are not sensitive to the values of $\frac{\Delta}{c}$.

shows that habit formation and persistent shocks interact to generate more complicated dynamics, so that consumption and output start to exhibit hump-shaped response pattern and investment becomes far more volatile than consumption.

To evaluate the plausibility of preference shocks as the main source of business cycles, I also simulate the habit formation model and compare the simulated time series with the actual U.S. data. Let $\rho = 0.9$ and choose the variance of the innovations in the preference shocks such that the predicted output volatility matches the U.S. data.[6] The statistical properties of the simulated time series are summarized in Table 1, which shows that the model does a very good job in predicting the relative volatilities of consumption and investment. The model overpredicts the volatility of hours relative to output due to diminishing marginal product of labor.[7] Regarding the correlations with output as well as the autocorrelations of these variables, the model does a reasonably good job too.

Table 1. Selective Moments

	σ_x	σ_x/σ_y			$cor(x_t, y_t)$			$cor(x_t, x_{t-1})$			
	y_t	c_t	i_t	n_t	c_t	i_t	n_t	y_t	c_t	i_t	n_t
U.S.	0.016	0.53	3.36	0.87	0.92	0.96	0.82	0.90	0.86	0.89	0.82
Model	0.016	0.56	3.68	1.38	0.65	0.90	0.99	0.80	0.95	0.74	0.78

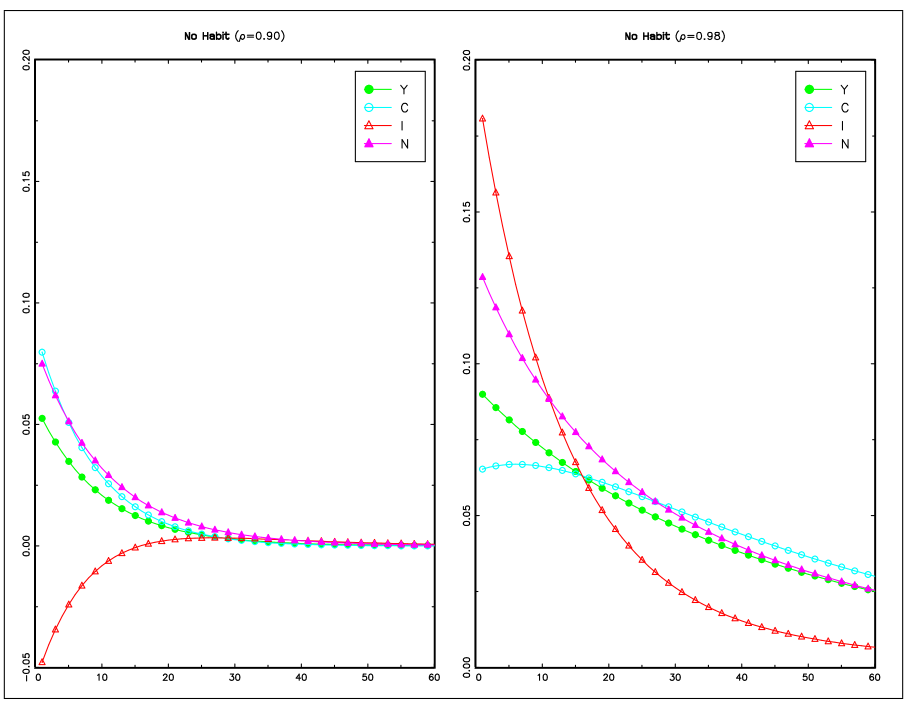

Figure 1. Impulse Responses without Habit Formation (left window: $\rho = 0.9$; right window: $\rho = 0.98$).

[6] The required standard deviation of the innovation is 0.04.

[7] To explain procyclical labor productivity by demand shocks, labor hoarding and capacity utilization are necessary. See Wen (2004) and Nakajima (2004) for such analyses.

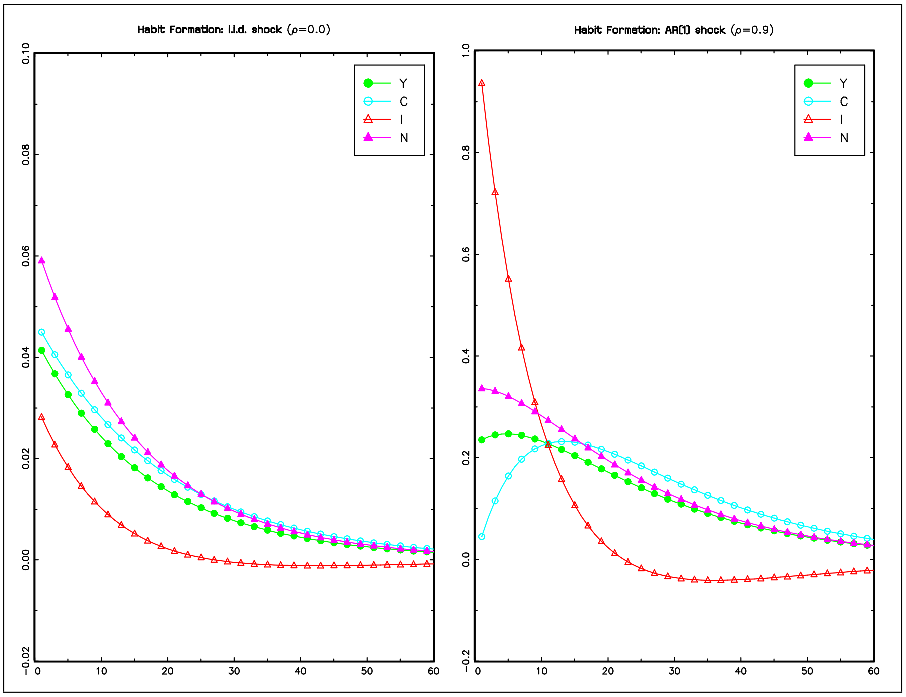

Figure 2. Impulse Responses with Habit Formation (left window: ρ=0.0; right window: ρ=0.9).

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